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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of: **Kiyoshi IRINO**

Group Art Unit: **2815**

Serial No.: **09/428,052**

Examiner: **Jose R. Diaz**

Filed: **October 27, 1999**

Confirmation No.: **4139**

For: **METHOD OF FABRICATING A SEMICONDUCTOR DEVICE CONTAINING NITROGEN IN A GATE OXIDE FILM**

Attorney Docket No.: **970901A**
Customer Number: **38834**

REQUEST FOR RECONSIDERATION

Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

June 18, 2004

Sir:

In response to the Office Action dated March 24, 2004, applicant requests favorable reconsideration of the above-identified application. Claims 6, 10 and 15-18 are pending.

Claims 6, 15 and 16 are now rejected under 35 USC §103(a) as being unpatentable over Ito et al. (U.S. Patent No. 5,650,344) in view of Wristers et al. (U.S. Patent No. 5,674,788). The rejection is respectfully traversed.

The Examiner summarizes the portions of Ito et al. on page 3 of the Office Action which are considered to correspond to the claimed step. Although the first embodiment of Ito et al. introduces the nitrogen atoms prior to the step of introducing impurity element, the Examiner cites an alternative embodiment of Ito et al. at column 5, lines 55-62.

The Examiner acknowledges that Ito et al. does not teach the claimed thermal annealing process conducted in an atmosphere containing NO. As such, Wristers et al. is applied for allegedly teaching that it is well known to conduct a nitridation process in an atmosphere containing NO.

With regard to claim 6, in which the gate insulation film is annealed in an NO ambient, the nitrogen atoms are introduced into the gate oxide film, and the nitrogen atoms thus introduced concentrate at the interface formed between the gate oxide film and the silicon substitute. Thereby, the dangling bonds at the foregoing interface are effectively terminated.

Ito teaches a nitridation process of a gate oxide film by exposing the gate oxide film to an NH_3 ambient. According to the process of Ito, however, not only the nitrogen atoms but also the hydrogen atoms are incorporated into the gate oxide film at the same time, while the hydrogen atoms thus incorporated react with the defects at the foregoing interface and cause formation of unwanted interface states. When such interface states are formed, the efficiency of termination of the dangling bonds by the nitrogen atoms is degraded.

Wristers et al. (US 5,674,785) teaches the growth process of an SiN film on a silicon substrate surface annealed in an NO ambient. There is no teaching at all in Wristers et al. to induce concentration of nitrogen at the interface between the gate oxide film and the silicon substrate by introducing nitrogen into an existing gate oxide film.

With regard to claim 15, formation of the interface states caused by contamination is successfully avoided by conducting the deposition of an oxide film without changing the ambient used at the time of introducing nitrogen into the gate oxide film, back to the atmospheric ambient. Thereby, the nitrogen atoms are effectively concentrated to the interface between the gate oxide film and the silicon substrate. The combination of art does not teach or suggest the features of claim 15.

In addition, Wristers et al. would teach away from employing NO in a step to introduce N atoms into a gate oxide film. See column 4, lines 27-34, which teaches that processes employing thermal nitridation of pre-existing oxides using NO cannot achieve a sufficient nitrogen concentration

at an upper surface. Furthermore, although the invention of Wristers et al. employs NO, the NO is used to grow an oxynitride layer. Thus, Wristers et al. would not provide any motivation to employ NO so as to introduce nitrogen atoms into an existing oxide film.

Claims 10, 17 and 18 were rejected under 35 USC §103(a) as being unpatentable over Duane (U.S. Patent No. 5,804,496). Page 5 of the Office Action contains the Examiner's characterization of the portions of Duane which are considered relevant to these claims. Favorable reconsideration of this rejection is respectfully requested.

With regard to claim 10, in which ion implantation process is used for introducing the nitrogen atoms into the gate oxide film, the nitrogen atoms introduced into the gate oxide film are concentrated to the interface between the gate oxide film and the silicon substrate, and the dangling bonds are effectively terminated at the interface.

Duane, on the other hand, teaches a nitridation process of the gate electrode by introducing the nitrogen atoms to the sidewall surface of the gate electrode by ion implantation process.

According to this technology of Duane, the sidewall part of the gate electrode forms a shadow at the time of the ion implantation process and it becomes difficult to introduce the desired amount of nitrogen atoms into the gate oxide film right underneath the sidewall part of the gate electrode.

According to the technology of this reference, the dangling bonds in the vicinity of the drain edge, where the problem of carrier trapping becomes conspicuous, cannot be terminated effectively.

The Examiner characterizes Duane as teaching introducing N atoms 219 into said gate oxide film 203. However, Duane shows that it teaches that an edge dopant (which can be a nitrogen containing species) is implanted into the edges 205a of the gate electrode 205. As such, Duane does not teach the step of introducing N atoms into said gate oxide film.

It may be the Examiner's position, however, that some N atoms may inevitably be introduced into the gate oxide film when the edge portions 205a are doped. In this event, contrary to the Examiner's assertion, it would not have been obvious to one of ordinary skill in the art to conduct the ion implantation at an acceleration voltage not exceeding 10keV. Duane teaches that the nitrogen containing species may be implanted at approximately 50keV and a concentration of 1E14 to 1E16 atoms/cm^2. Since this implantation is directed to doping the edge portions 205a, it would not have been obvious to conduct ion implantation at the claimed acceleration voltage since Duane is not concerned at all with introducing N atoms into the gate oxide film.

For at least the foregoing reasons, the claimed invention distinguishes over the cited art and defines patentable subject matter. Favorable reconsideration is earnestly solicited.

Should the Examiner deem that any further action by applicant would be desirable to place the application in condition for allowance, the Examiner is encouraged to telephone applicant's undersigned attorney.

In the event that this paper is not timely filed, Applicant respectfully petitions for an appropriate extension of time. Please charge any fees for such an extension of time and any other fees which may be due with respect to this paper, to Deposit Account No. 50-2866.

Respectfully submitted,

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